WEST FARGO
POTABLE WATER SOURCE ASSESSMENT

Prepared for:

CITY OF WEST FARGO

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TABLE OF CONTENTS

PAGE

FIGURES AND APPENDICES

EXECUTIVE SUMMARY

Background and Purpose. The City of West Fargo is a rapidly growing community with limited available water supplies. It is in the untenable position where its existing groundwater and surface water permits cannot meet projected 2050 demand. Furthermore, West Fargo Aquifer levels are declining and the Sheyenne River seasonally has insufficient flow to meet existing needs. The US Department of the Interior Bureau of Reclamation has conducted a comprehensive study of water needs for the Red River Valley in North Dakota and identified possible solutions for the region. The alternative preferred by the State of North Dakota and the Lake Agassiz Water Authority (LAWA) is one that includes regional use of existing water resources, supplemented with Missouri River water. The City wants to evaluate potential alternative sources for its own use prior to committing to join LAWA in this endeavor. The purpose of this study is to assist the City in evaluating its water supply options.

Growth and Demand. The City of West Fargo projects that its population will increase to nearly 35,000 in 2050. With this growth, annual average water consumption is expected to increase to 3,826 acre-feet (ac-ft) with a maximum daily consumption of about 10 million gallons per day (MGD).

Available Water Supplies. The City of West Fargo has two permits to withdraw water from the Sheyenne River and three permits for groundwater withdrawal. These total an annual withdrawal limit of 3,389 ac-ft and a daily limit of about 6 MGD.

Groundwater has always been the sole source of water supply for the City of West Fargo. Much work has been done by the State Water Commission to evaluate the extent and characteristics of the West Fargo Aquifer and its various units. The City has also completed much work in maximizing the performance of existing well locations, and installing new wells at selected locations to supplement existing supplies. Available studies indicate the West Fargo Aquifer consists of buried glacial melt-water channels that generally trend north to south and are bounded by lower permeability glacial till deposits. The aquifer system is overlain by relatively low-permeability lake deposits or glacial till materials that greatly limits recharge to the aquifer. Historically, the West Fargo Aquifer was an artesian (confined) aquifer system. Groundwater withdrawals have over time lowered the pieziometric head of the aquifer by as much as 100 feet, such that unconfined or water table conditions now exist. Groundwater withdrawals clearly exceed natural recharge rates indicating aquifer mining from existing use. As such, the West Fargo Aquifer system is not a reliable long-term source of water for the City and its current and projected water needs.

The City of West Fargo clearly needs additional sources of water. The purpose of this investigation is to investigate the potential to utilize storm water runoff and/or the Sheyenne River for municipal water supply.

Hydrologic modeling of the City of West Fargo storm water runoff was conducted using SLAMM and composite stormwater samples were collected and analyzed for potential pollutants. Inputs to the SLAMM model assumed 2050 urban development and used daily rainfall data from the 70-year period 1931 to 2001. Storm water was eliminated as a potential water source because a) it is an inconsistent supply source, particularly during drought periods when demand is highest and supply lowest, b) potential volumes available are insignificant in comparison to annual needs and volumes available from other sources, c) technical difficulties capturing and collecting the storm water runoff due to small, flat, interconnected storm sewers with multiple discharge points to receiving waters, and d) concerns of pollutants that may get into the urban stormwater.

The Sheyenne River is the only viable local long-term source of water. The volume of available water was determined, for the purposes of this study, using the naturalized flow developed by the US Geological Service (USGS). The naturalized flow is water that would reach the City of West Fargo if there were no Baldhill Dam and if there were no other upstream users. It represents what the river can provide to all users. Permitted municipal uses and the US Army Corps of Engineers (USACOE) required minimum flow are subtracted from the naturalized flow to determine the volume of water potentially available to the City of West Fargo.

Historical stream flow measurements show that, even in drought years, the Sheyenne River carries enough water to serve the City of West Fargo, but the timing of water availability does not match demand. This illustrates the need for long-term storage. Analysis of projected annual average demands and worst-case drought supplies indicate 5,200 ac-ft of surface storage is required to meet municipal water demands in 2050.

A similar analysis was conducted using the West Fargo aquifer for storage. Under this scenario, excess Sheyenne River water would be treated and injected into the aquifer, and recovered later when the Sheyenne River flows are not available. Both surface storage and aquifer storage are needed, but the size of surface storage ponds is reduced to 1,000 ac-ft when replenishing the aquifer over a long-term period.

Cost Comparison. The US Department of the Interior Bureau of Reclamation investigated several alternatives to supply water to eastern North Dakota. The alternative preferred by the State and by the LAWA is the GDU Import to the Sheyenne River, which is the least cost of the alternatives considered. Under Scenario Two the diversion to Lake Ashtabula would be sized to provide enough water to meet 100% of the projected average 2050 demand for the City of West Fargo. The Baldhill Dam would be operated to release the water from Lake Ashtabula as needed to meet peak and fluctuating demands. Total water user charges are estimated at $1.17/1,000 gallons or $381/ac-ft of raw water supplied.

To compare options in a consistent manner, a net present value analysis of future cash flows was conducted – essentially estimating how much money would be required today to meet all future construction and operating costs considering the time value of money.

The net present value of the GDU Import to the Sheyenne River project to the City of West Fargo is estimated at approximately $24 million. This corresponds well with the $1.17/1,000 gallons and $381/ac-ft presented in the *Final Report on Red River Valley Water Needs and Options.* The net present value of the Sheyenne River/West Fargo Aquifer ASR project is estimated at $26 to $34 million depending on whether a synthetic liner is needed for surface storage ponds.

Conclusion and Recommendation. The City of West Fargo has two viable options for long-term water supply. One is to reserve capacity in the GDU Import to the Sheyenne River project in an amount sufficient to meet its 2050 water supply needs. The other is to use Sheyenne River water and West Fargo aquifer storage and recovery.

It is recommended the City of West Fargo join other communities in the GDU Import to the Sheyenne River project for all of its projected water needs.

1.0 PURPOSE AND SCOPE

The City of West Fargo faces a challenge in determining how to provide municipal water to its residents as the City grows over the next several decades. The City currently uses groundwater wells as its exclusive water supply source. Aquifer water levels are decreasing and it is known that continued use of the West Fargo Aquifer as the sole source of water is not a reliable long-term option for the City.

The US Department of the Interior Bureau of Reclamation has conducted extensive research into a plan to divert water from the Missouri River to provide raw water to residents of the Red River Valley. The Bureau has completed the *Final Report on Red River Valley Water Needs and Options* and the *Draft Environmental Impact Statement: Red River Valley Water Supply Project.* These documents assess the needs, evaluate several water supply options, assess environmental impacts and estimate project costs. Project development has reached the point that Red River Valley municipalities must determine whether to participate in the project, and if so, at what level.

The City of West Fargo has asked Liesch Associates, Inc. to assist in this determination by evaluating the feasibility of two new sources of water to augment or replace the City's existing groundwater sources. These new sources are the Sheyenne River and storm water runoff from select areas within and near the City.

2.0 STUDY APPROACH

This study, the West Fargo Potable Water Source Assessment, evaluates available water resources water quality and availability and provides a preliminary review of needed infrastructure to utilize surface water as a source of potable water supply.

The City has long known that the existing sources of groundwater supply will need to be augmented to meet future water demand and ultimately may need to be replaced. Available information suggests that current groundwater withdrawals exceed recharge in the West Fargo Aquifer. Water levels have steadily declined and now portions of the aquifer are being converted from artesian to water table conditions. This situation, combined with the rapid growth rate in West Fargo, indicates a need for continued investigation of additional water sources.

Some time ago, the City acquired rights to a portion of the flow from the Sheyenne River. The Sheyenne River is classified as an intermittent stream, so by definition the river may not flow throughout the year. Water quality and availability will likely vary significantly from season to season and from year to year such that the City's allocation may not be available at certain times due to drought and competing uses for the water.

Stormwater runoff is an untapped potential source of municipal water. The City wants to "think outside the box" and consider innovative sources in its efforts to address the water shortage. As with the Sheyenne River, storm water availability is intermittent and the water quality is variable from one location to another and one storm event to another.

Due to the intermittent supply of both the Sheyenne River and stormwater runoff, using either as a raw water source will require large volumes of raw water storage. Either source will also require water treatment different than is provided today for the groundwater supplies the City uses. To the extent these sources are suitable from a quantity and quality standpoint, this study considers pumping, storage and treatment requirements to determine whether they are feasible water supply options.

Like the work done by the Bureau of Reclamation, this study assumes a severe drought like was experienced in the 1930s when evaluating the availability of Sheyenne River and stormwater runoff volumes. It also is looking for a long-term solution, and uses a year 2050 planning horizon, as the Bureau studies have done.

The characterization of the two potential sources included: a) collecting and reviewing existing data; b) estimating and characterizing the available quantity of water from the Sheyenne River and local storm water runoff; and c) assessing and characterizing water quality associated with the Sheyenne River and storm water runoff relative to drinking water standards.

The following are some of the information collected, compiled and reviewed as part of this investigation:

- Sheyenne River flow records from the United States Geological Survey (USGS)
- Sheyenne River water quality records from the USGS
- West Fargo water use per capita, including trends
- Population trends for West Fargo and surrounding communities
- MCLs, SMCLs and United States Environmental Protection Agency (USEPA) surface water treatment standards (Safe Drinking Water Act) for drinking water
- West Fargo aquifer current and projected well capacities, and projections for aquifer depletion
- West Fargo trunk storm sewer plans and profiles
- North Dakota State Water Commission water rights information, laws and treaties relative to the Sheyenne River and the City of West Fargo
- North Dakota State Water Commission permits for Sheyenne River and West Fargo aquifer withdrawals
- City planning and zoning maps for existing and planned future development
- Final Report on Red River Valley Water Needs and Options and its appendices
- Research on the potential for wastewater recycling and storm water re-use to reduce demands on potable water systems

Naturalized flow data developed by the USGS for the Sheyenne River were the basis for assessing available water supplies from the Sheyenne. The naturalized flow is water that would reach the City of West Fargo if there were no Baldhill Dam at Lake Ashtabula and if there were no other upstream users. It represents what the river can provide to all users. Permitted municipal uses and the USACOE required minimum flow are subtracted from the naturalized flow to determine the volume of water potentially available to the City of West Fargo.

The quantity of stormwater available was determined using historic rainfall records and continuous computer model simulations. The continuous flow model SLAMM was used to determine runoff volumes. Inputs assumed full development of the West Fargo Comprehensive Plan. Historic rainfall conditions were used, including the drought years of the 1930s, to compute storm water runoff volumes.

The assessment of the Sheyenne River and storm water runoff water quality was done using historical monitoring data on the Sheyenne River and spring and summer 2006 samples collected from each source and analyzed for an array of drinking water standard analyses.

A preliminary assessment of facilities needed for surface water utilization was then conducted. It estimated West Fargo water shortages and how the alternative water supplies could be used to meet these shortages. It included estimates of storage capacities and delivery (pumping, piping, etc.) capacities needed to meet future water demands.

Determining the feasibility of an alternative water source also requires an assessment of its costs. In this assessment, since a new source is required, the comparison is between a new alternative source of water and the Red River Valley Water Supply Project proposed by the US Department of the Interior.

3.0 BACKGROUND/INTRODUCTION

The population in the eastern 13 counties of North Dakota is projected to increase by more than 50% over the next 50-years, increasing from 272,300 to 417,600. This large increase in population, as well as projected increases in industrial water usage, creates large increases in demand for water. This growing demand and the limited water availability from the Red River of the North, the Sheyenne River and area aquifers led the to the enactment of the Dakota Water Resources Act of 2000. Under this act the US Department of the Interior Bureau of Reclamation was directed to conduct a comprehensive study of the water quality and quantity needs of the Red River Valley in North Dakota and possible options for meeting those needs. In compliance with this mandate, it published the *Final Report of Red River Valley Water Needs and Options* in November 2005, which outlines seven potential options for the region. The State of North Dakota has selected one of those – the GDU Import to Sheyenne River – as the preferred alternative. The Federal government has yet to identify its preferred alternative pending the Record of Decision on the Final Environmental Impact Statement. The GDU Import to Sheyenne River option would use a combination of Red

River, Sheyenne River and local aquifers, supplemented with Missouri River water to meet future water demands. The principal feature of this option is a pipeline from the McClusky Canal to Lake Ashtabula that would release Missouri River water into the Sheyenne River. The pipe would be sized so peak day demands could be met by Lake Ashtabula releases. The total estimated cost of the project is $430 million with operation, maintenance and replacement costs of $3.8 million per year.

The population of West Fargo is projected to grow by 230% from 14,940 in 2000 to 34,075 in 2050. Projected peak water demand is almost 10 mgd. The City of West Fargo is in the untenable position where their surface water permit and their ground water permit combined cannot meet 2050 peak water demand. Furthermore, the West Fargo Aquifer water levels and well field production are declining and the Sheyenne River (without the GDU Import) has insufficient flow to refill Lake Ashtabula during drought years, limiting its ability to provide sufficient flow to meet existing permits. However, even with these shortages and declining groundwater production, there is too much water almost every spring. Spring rainfalls and snowmelt, along with downstream blockages and very flat river gradients combine to cause severe spring flooding. It is in this paradox that the City of West Fargo must decide whether to join the LAWA in committing to the GDU Import to the Sheyenne River project, and if so, for what quantity of water.

This project's purpose is to assess water supply sources for the projected 2050 demand to help the City of West Fargo make this decision.

4.0 REGIONAL GROWTH AND DEMAND

The census data for the City of West Fargo shows phenomenal growth in population since 1940, growing from under 1,000 inhabitants to nearly 15,000 by the 2000 census. The City expects similar growth into the future due to its flood control measures on the Sheyenne River and its unconfined western corporate boundary. The City projects a 2050 population of 34,705, an increase similar to the previous 50-years. **Table 1** lists census data for the City from 1940 to its estimated 2004 population of 20,300 and projected 2050 population.

Table 1. West Fargo Census Data

Census Year	Census Population
1940	707
1950	1,032
1960	3,328
1970	5,151
1980	10,099
1990	12,287
2000	14,940
2004	20,300 (estimated)
2050	34,705 (projected)

A system capacity analysis was prepared for the City of West Fargo in January 2006. **Table 2** summarizes the historic demands and projected 2050 demands from this analysis. The projected average annual water demand assumes consumption will remain at approximately 98.3 gallons/capita/day through 2050. In addition to annual demands, the maximum monthly consumption and the maximum daily consumption are:

2050 Maximum Monthly Consumption: 710 acre-feet[1]

2050 Maximum Daily Consumption: 30 acre-feet (10 mgd)[2]

[1] Based on historic peak monthly per capita use of 215 gpcd (*USDI Final Needs and Options Report*, Appendix A, pp A-127 to A-128)
[2] Based on historic peak daily per capita use of 283 gpcd (*USDI Final Needs and Options Report*, Appendix A, pp A-127 to A-128)

Table 2. Projected 2050 and Maximum Historical Demand

	Projected 2050 Average Annual Demand, ac-ft	Maximum Historical Demand (1988), ac-ft
January	267	254
February	239	233
March	267	261
April	275	265
May	347	376
June	374	412
July	433	710
August	449	495
September	320	304
October	307	333
November	278	291
December	271	284
Annual	**3,826**	**4,219**

5.0 EXISTING MUNICIPAL WATER PERMITS

This analysis assumes that the primary users of Sheyenne River water during an extended drought would be the current municipal permit holders as summarized in the **Table 3**. The North Dakota State Water Commission permits include limits on annual withdrawal volumes and maximum daily withdrawal rates, both serving to limit water taken from the river.

Table 3. Sheyenne River Municipal Water Permits.

	North Dakota State Water Commission Permit No.	Annual Allocation, ac-ft	Maximum Allowable Withdrawal Rate, gpm
Fargo	1091	35,880	48,470
	4718	7,000	11,250
Lisbon	3588	373	600
Valley City	1096	6,686	13,464
West Fargo	921	954	700
	921A	1,460	700

Since 1950, Lake Ashtabula has served as a reserve source of water for municipal permit holders. With the completion of the Baldhill Dam, the impounded water has served as a back-up source for the municipalities that originally invested in the project. This water was allocated under the Thompson-Acker Plan, on a trial basis under a non-binding agreement, as shown in **Table 4**. These allocations were made in the late 1940s, with 75% of the allocation based on population and 25% based on investment in the project. The table shows the original allocation and the change in population since the construction of the dam and creation of the lake.

Table 4. Thompson Acker Plan for Lake Ashtabula.

City	Original Allocation, %	Allocation, ac-ft*	1950 Census	2000 Census	2050 Population Projection
Fargo	56.1	35,880	38,256	90,599	182,400
Grand Forks	31.3	20,023	26,836	49,321	83,800
Valley City	10.5	6,686	6,951	6,826	5,840
West Fargo	1.5	954	1,632	14,940	34,705
Lisbon	0.6	373		2,292	2,530

* Estimate that Lake Ashtabula would have about 64,000 acre-feet for municipal use.

By any method of comparison, the 2000 census data and the 2050 population projections don't support the original allocation of water from Lake Ashtabula.

<u>**West Fargo Permits.**</u> The City of West Fargo has two permits to withdraw water from the Sheyenne River and three permits for groundwater withdrawal as shown in **Table 5**.

Figure 1 shows permitted water supplies and 2050 average annual water demand. Neither the groundwater permits nor the Sheyenne River permits alone can meet projected demand. Even combined, available permit capacity cannot meet projected demand during the high-demand summer months.

Table 5. West Fargo Permits.

	Permit #	Annual Permit Allocation, ac-ft	Avg Monthly Allocation, ac-ft	Maximum Permitted Rate, gpm
Sheyenne River	921 921A	954 1,460	201	700 700
West Fargo Aquifer	1103 1900 3585	60 565 850	123	700 565 1,500
Total		**3,889**	**324**	**4,165**

6.0 WATER AVAILABILITY

The City of West Fargo has permits to withdraw water from the Sheyenne River and the West Fargo Aquifer. Water may also be available from other sources, including storm water runoff, wastewater re-use and water conservation.

Water Conservation. Water conservation, while not a source of new water, has the same effect of reducing the demand on existing sources. Water conservation was not included in the scope of services for this investigation, but is nonetheless a management tool available to municipalities when needed. The Bureau of Reclamation and the City of West Fargo considered water conservation in the development of projected water demands.

Wastewater Reuse. Wastewater reuse, while not included in the scope of services for this investigation, was considered as a possibility. Wastewater provides a relatively consistent source of water that relatively closely matches demand volumes. However, there is not much precedent for using wastewater as a primary source for a public water supply. Furthermore, there are potential technical problems and likely negative public perception with this option. Wastewater reuse would need investigation beyond the scope of this study to be considered a viable long-term water supply option for the City of West Fargo. This could be part of a more in-depth future study.

Groundwater. Groundwater has always been the sole source of water supply for the City of West Fargo. Much work has been done by the State Water Commission to evaluate the extent and characteristics of the West Fargo Aquifer and its various units. The City has also completed much work in maximizing the performance of existing well locations, and installing new wells at selected locations to supplement existing supplies. Available studies indicate the West Fargo Aquifer consists of buried glacial melt-water channels that generally trend north to south and are bounded by lower permeability glacial till deposits. The aquifer system is overlain by relatively low-permeability lake deposits or glacial till materials that greatly limits recharge to the aquifer. Historically, the West Fargo Aquifer was an artesian (confined) aquifer system. Groundwater withdrawals have over time lowered the pieziometric head of the aquifer by as much as 100 feet, such that unconfined water table conditions now exist. This is shown in **Figure 2**, a hydrograph of a well located in the West Fargo North aquifer unit. The *Evaluation of the West Fargo Aquifer*

System (Liesch Associates, 1999) estimates the projected life of all West Fargo wells operating at an average of 250 and 500 gpm. Wells have an estimated 0 to 50 years of remaining life at 500 gpm and 10 to 80 years at 250 gpm. Projected life of individual wells is shown in **Appendix B**. The *Final Report on Red River Valley Water Needs and Options* states that, "with continued use the West Fargo North Aquifer could be depleted in 25 years to such an extent that its utility during a drought would be questionable". Groundwater withdrawals clearly exceed natural recharge rates indicating aquifer mining from existing use. As such, the West Fargo Aquifer system is not a reliable long-term source of water for the City.

Storm Water. Storm water runoff was considered as a potential alternative water source. Hydrologic modeling of the City of West Fargo was conducted using the computer model SLAMM. SLAMM was designed for small storms hydrology, computing runoff volumes using empirical rainfall/runoff data for urban land-uses. Storm water runoff volumes were computed for all storms between 1931 and 1940 using historical local rainfall records and planned 2050 urban development.

The analysis assumes collected stormwater would be temporarily stored in the storm sewer system and pumped to raw water storage prior to treatment. Using the existing storm sewer system for storage is complicated by the interconnected nature of the storm sewer system. Most of the storage would have to be done in the lower reaches near the river where the storm sewer pipes are largest. Preliminary analysis indicates the existing residential storm sewer system would have about 2.7 acre-feet of storage in the pipes closest (within 2,000 feet) to the Sheyenne River. This analysis assumed that the plugged storm sewer system would always be empty at the time of the next runoff event.

The model computed runoff volumes for each precipitation event during the period 1931 through 1940. A 0.05-inch rainfall event will generate 2.7 acre-feet of runoff and would fill the storm sewer system. Runoff in excess of the storm sewer storage capacity would bypass to the Sheyenne River. Precipitation events less than 0.05 inches have an average runoff of about 1.6 acre-feet. These very small storms represent about 50% of all precipitation events during the 10-year drought period.

Table 6 shows the estimated runoff volume for all precipitation events during the 10-years of drought from 1931 through 1940. The estimated volume captured reflects the limited capacity to store runoff in the storm sewer system. The average annual runoff volume captured is about 160 acre-feet. Most of the runoff occurs during the larger storm events that cannot be contained. The total annual runoff average of 1,800 acre-feet illustrates this point.

Table 6. Estimated Runoff Volume.

	Estimated Runoff Volume, ac-ft	Estimated Volume captured by the storm sewer, ac-ft
1931	2,467	160
1932	1,674	160
1933	1,743	170
1934	1,543	150
1935	2,437	170
1936	822	140
1937	2,441	190
1938	1,746	190
1939	1,156	130
1940	2,005	160

The estimated volume of captured runoff is a very small fraction of the West Fargo 2050 demand. Storm water was eliminated as a potential water source because:

1. It is an inconsistent supply source, particularly during drought periods when demand is highest and supply lowest.

2. Recoverable volumes are insignificant in comparison to annual needs and volumes available from other sources.

3. Technical difficulties capturing and collecting the storm water runoff due to small, flat, interconnected storm sewers with multiple discharge points to receiving waters.

4. Concerns that pollutants may find their way into the urban stormwater.

Sheyenne River. The extensive stream flow records for the Sheyenne River allow for its evaluation as a potential source of water. As noted earlier, the Sheyenne River is an intermittent stream and cannot be relied upon at all times of the year. Additionally, annual flow volumes can vary significantly from year to year. **Figure 3** shows annual flow volumes for a 70-year period of record. It illustrates occasional dry years throughout the period and the significant low flows of the drought decade from 1931 to 1940.

The Sheyenne River does not have enough flow to meet the average monthly demand. **Figure 4** shows projected monthly demand, average monthly flows during the 1930s drought and average monthly flows since the drought ended. **Figure 4** shows that the Sheyenne River flows do not meet demand for most months during severe drought periods, and has insufficient flow during late fall and winter months even during more normal hydrologic cycles.

In spite of these temporal water shortages, there are times of the year when the Sheyenne River has excess flow. **Figure 5** shows the same data shown in **Figure 4**, but with an arithmetic rather than logarithmic scale. It shows that, even during the drought decade, average monthly flows far exceed demands during spring runoff. **Figure 6** shows the cumulative annual available supply in both drought (1931-1940) and average years (1941-1993), along with the projected 2050 demand.

The flow rates and volumes in all of the figures represent water potentially available to the City of West Fargo. The numbers use the naturalized flow of the Sheyenne River developed by the USGS. The naturalized flow is water that would reach the City of West Fargo if there were no Baldhill Dam and if there were no other upstream users. It represents what the river can provide to all users. Permitted municipal uses and the USACOE required minimum flow are subtracted from the naturalized flow to determine the volume of water potentially available to the City of West Fargo.

The figures show that, even in drought years, there is sufficient water in the Sheyenne River for the City of West Fargo, but that the timing of water availability does not match demand. On the basis of these seasonal high flows, and the inadequacy of the local aquifers and local stormwater runoff, the Sheyenne River is the only viable long-term alternative source of water other than the GDU Import to the Sheyenne River. On the basis of the timing of water availability, there is a need for long-term storage, adding to the storage when water is plentiful and withdrawing it when water supplies are low.

7.0 WATER QUALITY

The water quality of potential alternate sources must be determined before they can be established as feasible water supplies. Water samples were collected from the Sheyenne River on April 25 and August 7, 2006. Composite urban storm-water runoff samples were collected on May 4th and August 18th, 2006. The collected samples were tested for a wide range of parameters including volatile organics, pesticides, herbicides, semi-volatile (base/neutral) organics, mercury, arsenic, ammonia, chloride, nitrate and many other inorganic parameters. The parameter list provides a broad look at water quality for potential impacts that could occur from urban and rural land use within the Sheyenne River watershed.

The results of the water quality sampling are summarized in **Appendix C**. Also provided for comparison are the Maximum Contaminant Levels (MCLs) as established by the USEPA for municipal water supplies. In general, the analytical data from the Sheyenne River are favorable in that there was no parameter found at concentration levels above the MCLs. There were no volatile organics, pesticides, herbicides or semi-volatile parameters detected, and inorganic parameters were generally not detected at significantly elevated levels. Sheyenne River water quality can of course be variable dependant upon many factors such as the timing of precipitation and runoff events relative to agricultural activities. However, overall the water appears suitable for municipal use with appropriate treatment and disinfections.

Results of the composite municipal storm-water sample can also be variable dependant upon local land use in industrial, commercial, and residential settings. The collected composite samples are from the Westwind Addition, which is primarily a residential setting. Similar to the Sheyenne River samples, the results for the stormwater sample indicate it to is likely suitable for municipal use with appropriate treatment and disinfections. However, as stated earlier, stormwater is no longer being considered a suitable source for municipal water supply for several reasons, including the logistics for capturing and routing water to storage and treatment facilities, the relative quantity of water that may be available, the greater potential for contaminants in the runoff from the variable urban land uses, and probable negative public perception.

8.0 STORAGE REQUIREMENTS

Since the Sheyenne River has sufficient annual volume to meet annual demand, and water quality is suitable for municipal water supplies, the Sheyenne River appears to be a suitable potential alternate source. As noted earlier, the City has permits for withdrawing water, but the permitted volume is insufficient to meet the projected demand. Also as noted above, the Sheyenne River exceeds municipal demands during periods of spring runoff, even during severe droughts, but does not have sufficient flows throughout the year to meet its demands. Storage of river water during periods of excess flow, to be used when the river has insufficient flow, is needed for the Sheyenne River to meet annual municipal demands. Two scenarios are considered, one using surface storage only, the other using surface storage for raw water and aquifer storage for treated water.

Surface Storage. The first scenario consists of diverting Sheyenne River water during seasonal high flows to large storage ponds. The water would be treated and distributed for municipal use, as it is needed.

A storage model was used to determine storage capacity needed to meet 2050 demands during drought conditions. The model assumes water can only be diverted from the Sheyenne River when there is sufficient flow to meet all other demands. The stored water is then used when the river flows are not sufficient to meet all demands. The model also includes evaporation losses, which during long drought periods and from large pond areas become very significant.

This analysis uses the naturalized flows of the Sheyenne River to estimate water available to the City. As noted earlier the USGS determined the naturalized river flows to illustrate what the river can provide to all users. The water available to the City of West Fargo is assumed to be the naturalized flow less all other users. Other uses include evaporation, all other municipal demands and the minimum base flows required to sustain aquatic life in the river.

The Bureau of Reclamation in their Draft Environmental Impact Statement noted that the USACOE determined 13 cubic feet per second (cfs) is necessary as a base flow to maintain aquatic life. The existing permit demand, according to the North Dakota State Water Commission, including West Fargo's permits, adds up to a total of 72 cfs in the Sheyenne River. The flow at which any new withdrawals must cease is the sum of the base flow and the existing municipal permits, 85 cfs. To fill a surface storage pond, the City would divert river water only when the Sheyenne River flows at

West Fargo exceeded 85 cfs. The City would need to modify existing permits or obtain new permits to withdraw this additional water from the Sheyenne River.

To estimate the storage volume, this analysis created a model using diverted river flows as inflows to a surface storage pond with withdrawals that included the West Fargo municipal demand and evaporation. This model simulates monthly supplies and demand during the drought decade of the 1930s, as well as the more normal hydrologic years since 1941.

The model inputs included the naturalized flows described earlier, estimated evaporation for Lake Ashtabula by the USGS, monthly demand for the City in 2050, minimum allowable river flows, diversion pump rates from the river to the surface pond, average annual municipal demand and pond evaporation. **Figure 7**, a fill and draw diagram shows the results of this analysis. Assuming the ponds are full at the beginning of the drought period, approximately 5,200 acre-feet of storage are required to meet municipal demand throughout the drought. **Figure 8** shows the critical period of reservoir depletion during the worst of the drought.

The very flat topography in the region makes constructing large volumes of storage very difficult and costly. It also requires a large area of land and would have large losses due to evaporation. There are, however, potential benefits of such a large reservoir, including aesthetics and recreation. Evaluation of the potential benefits of a large reservoir is beyond the scope of this study. Basing recommendations solely on water supply, there are options more cost effective than surface storage.

Aquifer Storage. While the West Fargo aquifer is not considered a viable long-term source of supply, it is available for temporary mining. This led to a concept of using the West Fargo aquifer for storage, injecting treated Sheyenne River water during normal years and mining it during drought years. Using the aquifer for storage dramatically reduces the size of surface storage needs.

The second scenario evaluates whether, through aquifer recharge and storage, combined surface and aquifer storage can enable the Sheyenne River to become a reliable source of potable water through 2050 without depleting the groundwater aquifer. While the Bureau of Reclamation considered aquifer storage and recovery (ASR) as part of regional alternatives, this question has not been addressed in previous studies specifically to meet the needs of the City of West Fargo.

The fundamental operation of the ponds is to store water from the Sheyenne River until it is treated. Water would be pumped into the ponds when flows exceed all other municipal permitted demands. The impounded water would be used to meet the municipal demands for West Fargo. Excess water would be treated and injected into the aquifer. When the Sheyenne River has insufficient flows, the City would meet the municipal demand with its wells. In effect, the surface pond provides temporary storage while the aquifer provides long-term storage, both meeting the demands of the City.

The same storage model used in the surface storage scenario was used to determine raw water storage requirements for the aquifer storage scenario. Like the first scenario, this analysis uses naturalized flows of the Sheyenne River. The analysis estimates the volume of water diverted to surface storage ponds, pumped from the pond to meet municipal demand, pumped from the pond and injected into the aquifer, and pumped from the aquifer to meet projected demand. Both water supplies and projected demands include a 1930s-type drought decade prior to 2050. The two criteria established for the simulation are a) to provide a continuous supply of water to meet West Fargo's demands, and b) replace all pumped groundwater with injected ground water.

Figure 9 shows that, when replenishing the aquifer over a 30-year period, 1,000 ac-ft of raw water surface storage is sufficient to meet demand that would include a severe 10-year drought. **Table 7** lists the general features of a storage pond that would temporarily store diverted river water to be treated for both groundwater injection and domestic consumption.

Table 7. Surface Storage of Diverted River Water

Pond Volume, ac-ft	1,000
Pond Mean Depth, ft	10
Pond Surface Area, ac	100
River Diversion Pump Rate, gpm	7,300
Municipal Pumping Rate, gpm	5,050
Injection Pumping Rate, gpm	1,550
Minimum Pond Volume when Municipal Demand ceases, ac-ft	100
Minimum Pond Volume when Ground Water Injection ceases, ac-ft	100

The simulation shows that, for the period of record beginning in 1930 to the present, the greatest volume available from the Sheyenne River occurred in 2000. That year the river flows were consistently high and well distributed, which would allow surface water to meet municipal demand and regular injection of treated water to the aquifer throughout the year. In contrast, in 1934, the year of lowest river flows, the City would have pumped 3,204 acre-feet of groundwater to meet domestic demand. Only 1,547 acre-feet of water would have been diverted from the river and only 418 acre-feet would have been injected into the aquifer.

Under this scenario, the City would need to increase its surface water and ground water permit volumes as noted in **Table 8** to meet expected 2050 domestic demand. It would also need to get approval for groundwater injection and storage.

Table 8. Existing and Projected Permit Volumes

	Permit #	Existing Permit Volume, ac-ft	Projected Permit Volume by Source, ac-ft
Sheyenne River	921 921A	954 1,460	6,880
Groundwater Use	1103 1900 3585	60 565 850	3,204
Groundwater Injection			2,500

9.0 OTHER REQUIRED INFRASTRUCTURE

Finished Water Storage. Finished water storage must accommodate treated water until it can be put into the distribution system or injected into the aquifer. For the purpose of this study, finished water storage of approximately one day of average municipal demand – approximately 3 million gallons in 2050, is assumed.

River Withdrawal Pumping Requirements. Pumping requirements from the Sheyenne River are estimated at 7,300 gpm. This rate is sufficient to fill the 1,000 ac-ft storage in about one month when river flows are sufficient. Total maximum year withdrawal is projected to be 6,880 ac-ft. Both the pumping rate and the total volume withdrawal exceed current permit limits of 1,400 gpm and 2,414 ac-ft, respectively.

Water Treatment Plant Capacity. The water treatment plant capacity should be designed to meet the maximum daily demand. The U.S. Department of the Interior determined the historic peak daily per capita use in West Fargo is 283 gallons/capita/day. Using projected 2050 population figures of 34,705; the treatment plant capacity needed is approximately 10 MGD. This provides a peaking factor of slightly more than three.

It is assumed that, whether Sheyenne River water or GDU Import to Sheyenne River water is the source, the type of water treatment plant will be similar. There would, however, be economies of scale if the water were treated at a large regional water treatment plant under the GDU Import to the Sheyenne River option.

Groundwater Well Capacity. Groundwater well capacity should also be capable of meeting peak daily demand. There will be times during peak demand when no surface water is available. As noted above, peak daily demand is projected to be nearly 10 MGD, or nearly 7,000 gpm. This exceeds the current permit limits of 2,765 gpm. New wells and additional permit authority will be required to meet the projected withdrawal needs.

Injection Well – Location, Design and Capacity. In considering groundwater injection, all injected water would first be treated to municipal water quality standards. Prior to permitting and implementing groundwater injection, many variables would require evaluation. In theory, water may be injected at volumes and rates approaching, or similar to, withdrawal capacities in an unconfined aquifer. In practice, injection rates would be expected to be lower than withdrawal rates from the municipal wells. The primary variables requiring evaluation would include identifying proper injection well locations relative to aquifer boundaries and withdrawal wells, taking into consideration the natural groundwater flow direction and gradients. The goal is to be certain that as much of the injected water as possible will be recovered by the water supply wells. Even so, a percentage of the water injected into the aquifer will not be recovered. The water that is lost will have been treated to drinking water standards at an expense to the City. Significant geological evaluation will be needed to estimate the loss of water in the aquifer.

10.0 GARRISON DIVERSION UNIT IMPORT TO THE SHEYENNE RIVER PROJECT

The alternative preferred by the State of North Dakota from the *Final Report on Red River Valley Water Needs and Options* is the GDU Import to the Sheyenne River, which is the least cost of the alternatives considered. Scenario Two, the larger of the scenarios considered is best suited to the City of West Fargo. Under this scenario, the diversion to Lake Ashtabula would be sized to carry 200 cfs, of which approximately 6 cfs would be designated for the City of West Fargo. A continuous 6 cfs is sufficient to provide 100% of the projected average 2050 demand for the City of West Fargo. It is assumed the Baldhill Dam will be operated to release the water from Lake Ashtabula as needed to meet peak and fluctuating demands.

The *Final Report on Red River Valley Water Needs and Options* prepared by U.S. Department of the Interior, Bureau of Reclamation presents its financial analysis in Appendix C. Table D of this Appendix shows projected costs for the GDU Import to the Sheyenne River (all costs are 2005 dollars). Total project capital costs to the users are approximately $585 million. Annual operation, maintenance and replacement costs are approximately $5 million/year. Total annual costs using grant money and Federal loans when available are approximately $33 million/year. This translates to a user charge of $1.17/1,000 gallons or $381/ac-ft of raw water supplied.

11.0 COST COMPARISON

In an effort to compare options in a consistent manner, this analysis assesses the cost of each as a net present value of future cash flows – essentially how much money would be required today to meet all future construction and operating costs considering the time value of money.

The net present value of the GDU Import to the Sheyenne River project to the City of West Fargo is approximately $24 million. This was determined using cost estimates prepared by EES Consulting and documented in its September 29, 2005 correspondence. This analysis uses the cash flows shown in the West Fargo analysis – the 200 cfs scenario and financing Option A. Bringing the capital costs back to present value ($923,769 annually for 40 years @ 5% and $393,484 annually for 40 years @ 5%) yields 2005 capital costs of $16.6 million for Phase I and $7.1 million for Phase

II. Annual operating, maintenance and replacement costs were estimated at $15,999/year. The long-term present value at 5% is $300,000, for a total combined present value of $24 million. This corresponds well with the $1.17/1,000 gallons and $381/ac-ft presented in the *Final Report on Red River Valley Water Needs and Options*.

The largest cost associated with the Sheyenne River/West Fargo Aquifer storage option is the construction of raw water storage ponds. Other major costs include lift stations, piping and controls for raw water into the ponds and from the ponds into the water treatment facility, ground storage tanks for finished water, groundwater injection wells, and additional new groundwater production wells. Construction costs are estimated at $10 million to $13.5 million depending on whether a synthetic liner is needed for the raw water storage ponds. To remain consistent with the cost estimating methodologies used in the *Final Report on Red River Valley Water Needs and Options*, several factors must be added, including contractor overhead and profit (30%), contractor costs (15%), unlisted items (5%), contingencies (25%), and non-contract engineering and administration (25%). With all these additional costs, the total construction cost becomes $25 to $33 million depending on whether a synthetic liner is needed.

Annual operating, maintenance and replacement costs consist on maintaining the ponds, power for water pumping, and maintenance and replacement allowances for the pumping and control equipment. These costs are estimated at $50,000/year. The long-term present value at 5% is $1 million, for a total combined present value of $26 to $34 million.

As noted earlier, capital costs associated with municipal water treatment are assumed to be the same whether the Garrison Diversion or Sheyenne River/West Fargo aquifer storage option is chosen. In either case the water will be withdrawn from the Sheyenne River and the treatment system will need to meet peak municipal demand. The operating costs for municipal water treatment will be higher for the Sheyenne River/West Fargo aquifer storage option due to treated water lost in the aquifer. The amount of this increased cost is unknown. It is estimated that an average of 1,500 ac-ft of treated water will be injected and withdrawn annually. At $2.50/1,000 gallons treated, each 1% lost costs the City approximately $12,200/year, with a long-term present value of $250,000.

12.0 CONCLUSION

The City of West Fargo has two viable options for long-term water supply. One is to reserve capacity in the GDU Import to the Sheyenne River project in an amount sufficient to meet its 2050 water supply needs. The other is to seek increased permit authority for both Sheyenne River and West Fargo aquifer withdrawals, using the Sheyenne River as the principal water source. It requires using the West Fargo aquifer for storage, injecting treated Sheyenne River water when it is plentiful and withdrawing it when surface water supplies do not meet municipal demands. Under either scenario, the City of West Fargo should plan to obtain all of its water from the selected source. The West Fargo Aquifer is confined and receives little or no natural recharge. As noted in the *Final Report on Red River Valley Water Needs and Options*, "This confined aquifer system has only a finite quantity of water in storage, and all withdrawals should be considered one-time removals of a non-naturally replenished resource".

There is significant work to be done to demonstrate the feasibility of the West Fargo aquifer storage and recovery option. This will require, among other things:

- Determine whether the City of West Fargo can obtain permits for additional Sheyenne River water, both peak rates and annual volumes, only taking the additional water during periods of high river flow.
- Determine whether the City of West Fargo can obtain permits to inject treated Sheyenne River water into the West Fargo aquifer.
- Determine whether the City of West Fargo can obtain permits for additional withdrawal from the West Fargo aquifer, both peak rates and annual volumes.
- Determine the compatibility of treated Sheyenne River water with the West Fargo aquifer, and what conditions must be maintained to keep the waters compatible.
- Determine continuity and extent of West Fargo aquifer buried glacial melt-water channels to identify potential locations for groundwater injection and retrieval.
- Determine whether land near the Sheyenne River typically has near surface clay deposits that could be used to line storage ponds.

The advantage of this option is that it allows the City of West Fargo to proceed on its own schedule, continuing to deplete the West Fargo aquifer in the near term while planning for the long term.

The other option is to join with the other communities in the region in the GDU Import to the Sheyenne River project. Under this option, water meeting 2050 projected demands, including lake evaporation, will be maintained in Lake Ashtabula and released as needed to meet peak regional demands. The treatment and distribution of water will be part of a regional system. The advantage of this option is that it appears to be less costly than the West Fargo aquifer storage and recovery option, there is less uncertainty regarding its feasibility, and others, most likely the Lake Agassiz Water Authority, will develop the infrastructure for the water supply, treatment and distribution.

The recommended course of action is for the City of West Fargo to join the other communities in the GDU Import to the Sheyenne River for all of its projected water needs.

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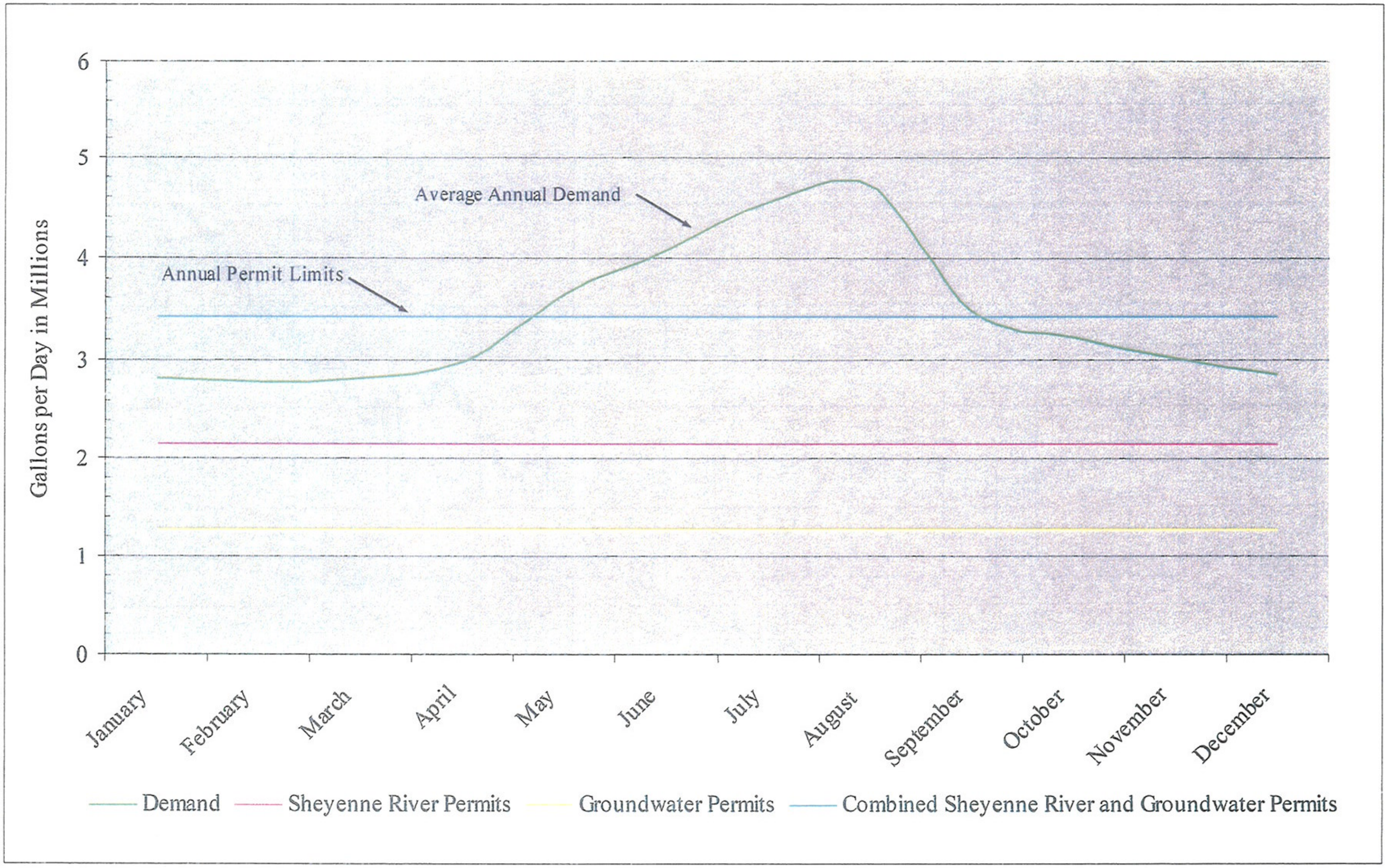

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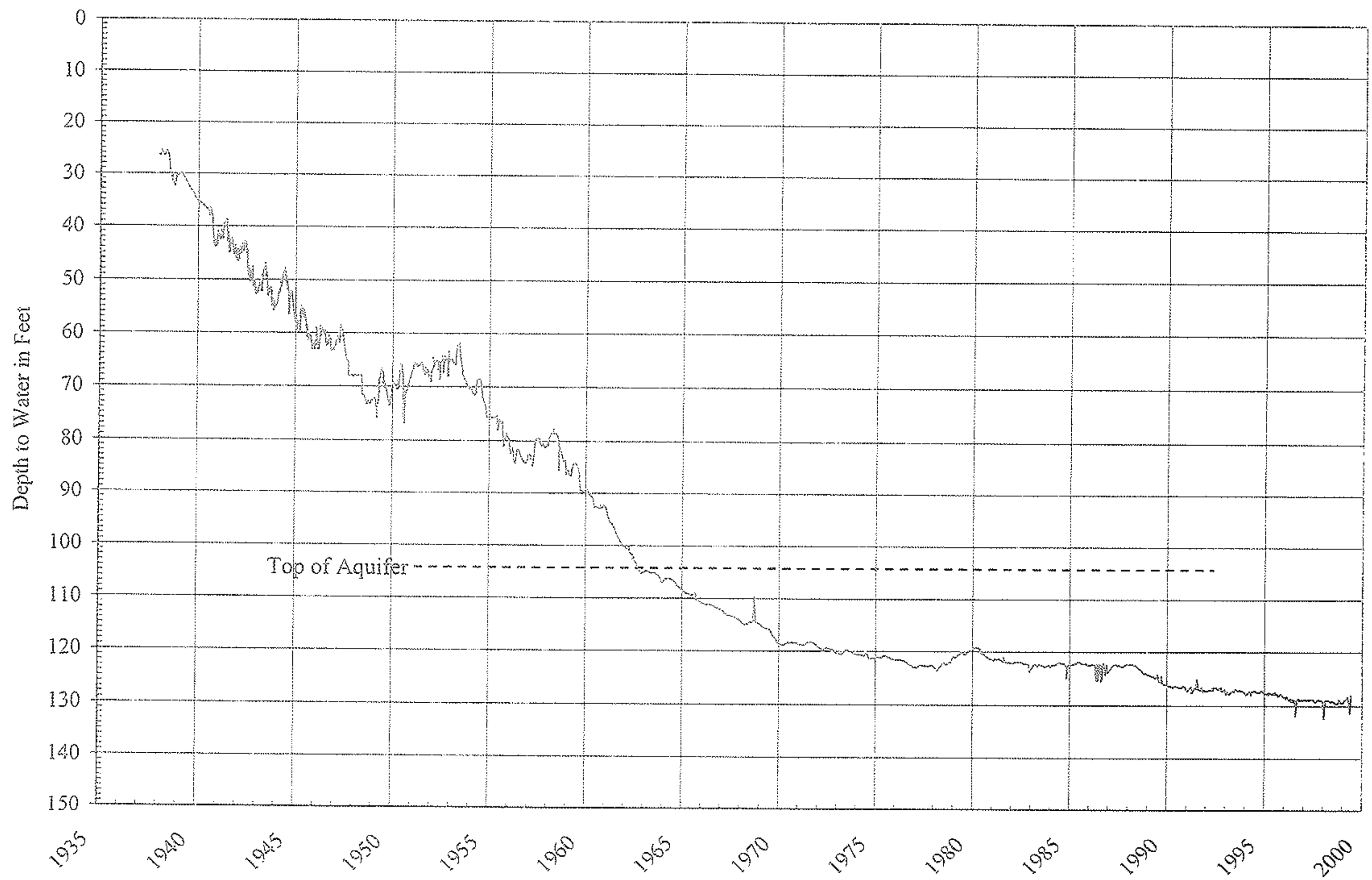
West Fargo: Potable Water Source Assessment	**Dec 06**
2050 Average Annual Demand and Annual Permit Limits	**Figure 1**



Source: Technical Memorandum: Evaluation of the West Fargo Aquifer System, Liesch Associates, Inc., August 13, 1999.

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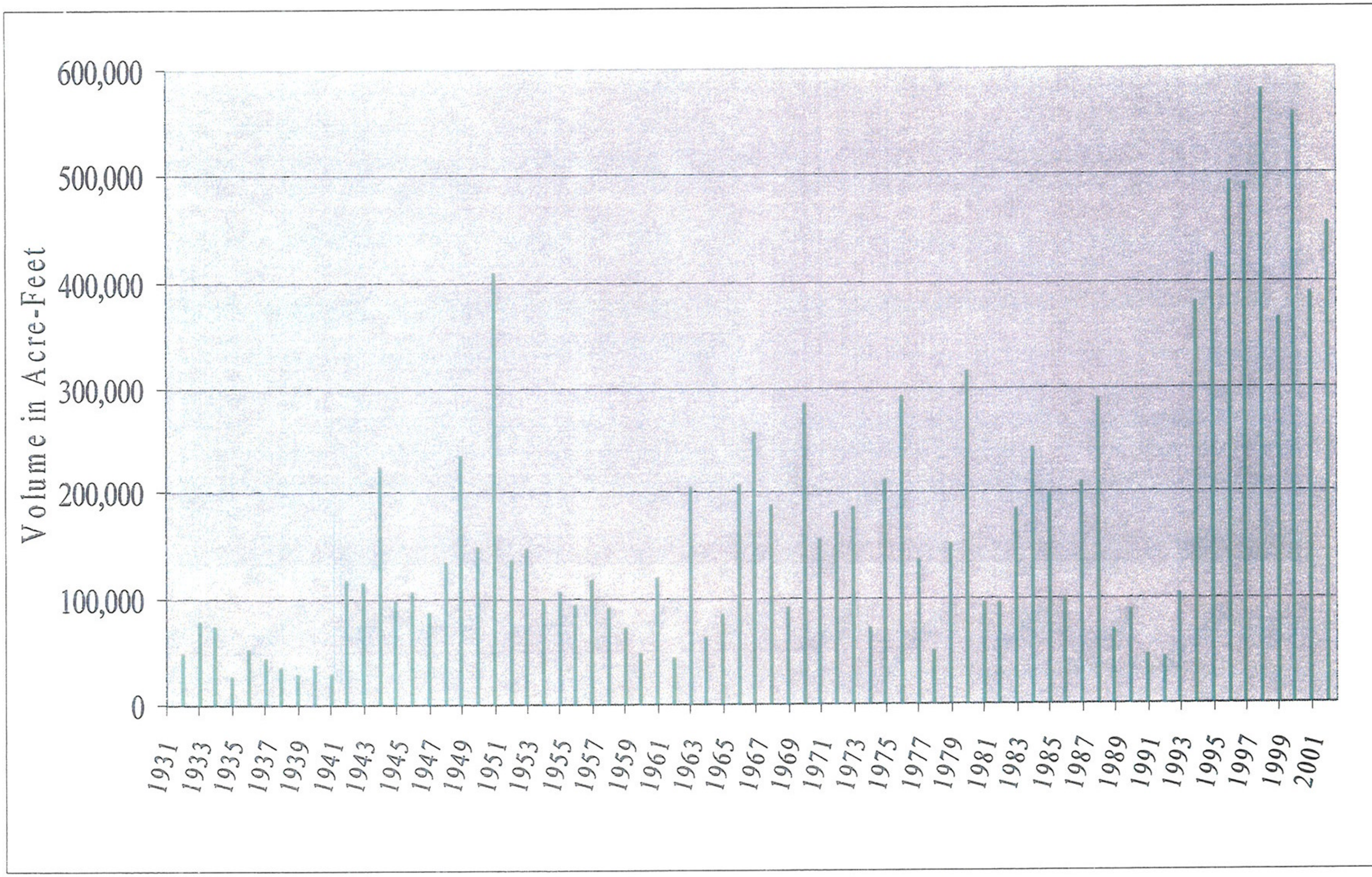
	Hydrograph of Well Located in T-139-N, R-49-W, Section 6	**Figure 2**



LIESCH Hydrogeologists • Engineers • Environmental Scientists	West Fargo: Potable Water Source Assessment	Dec 06
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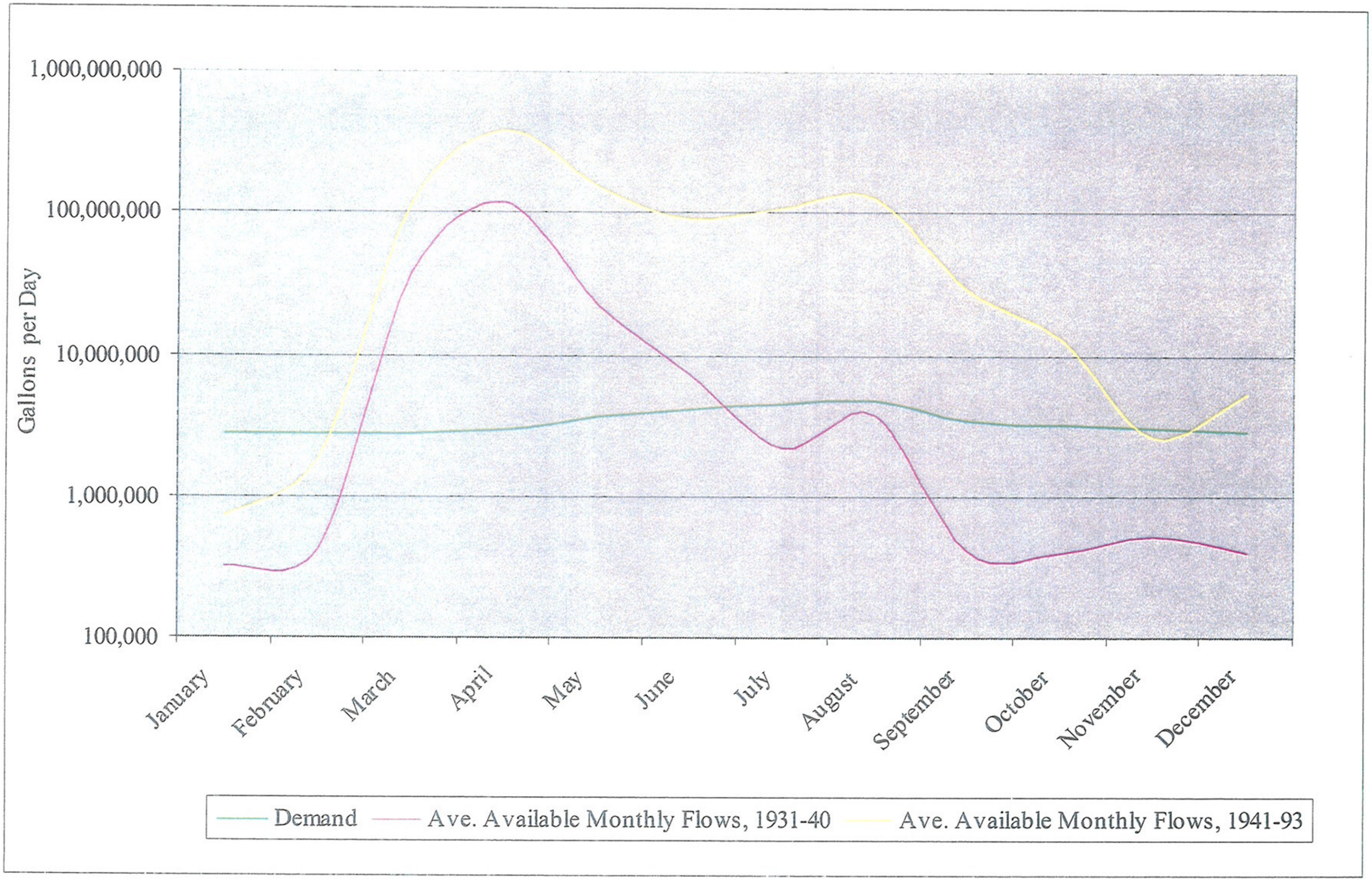

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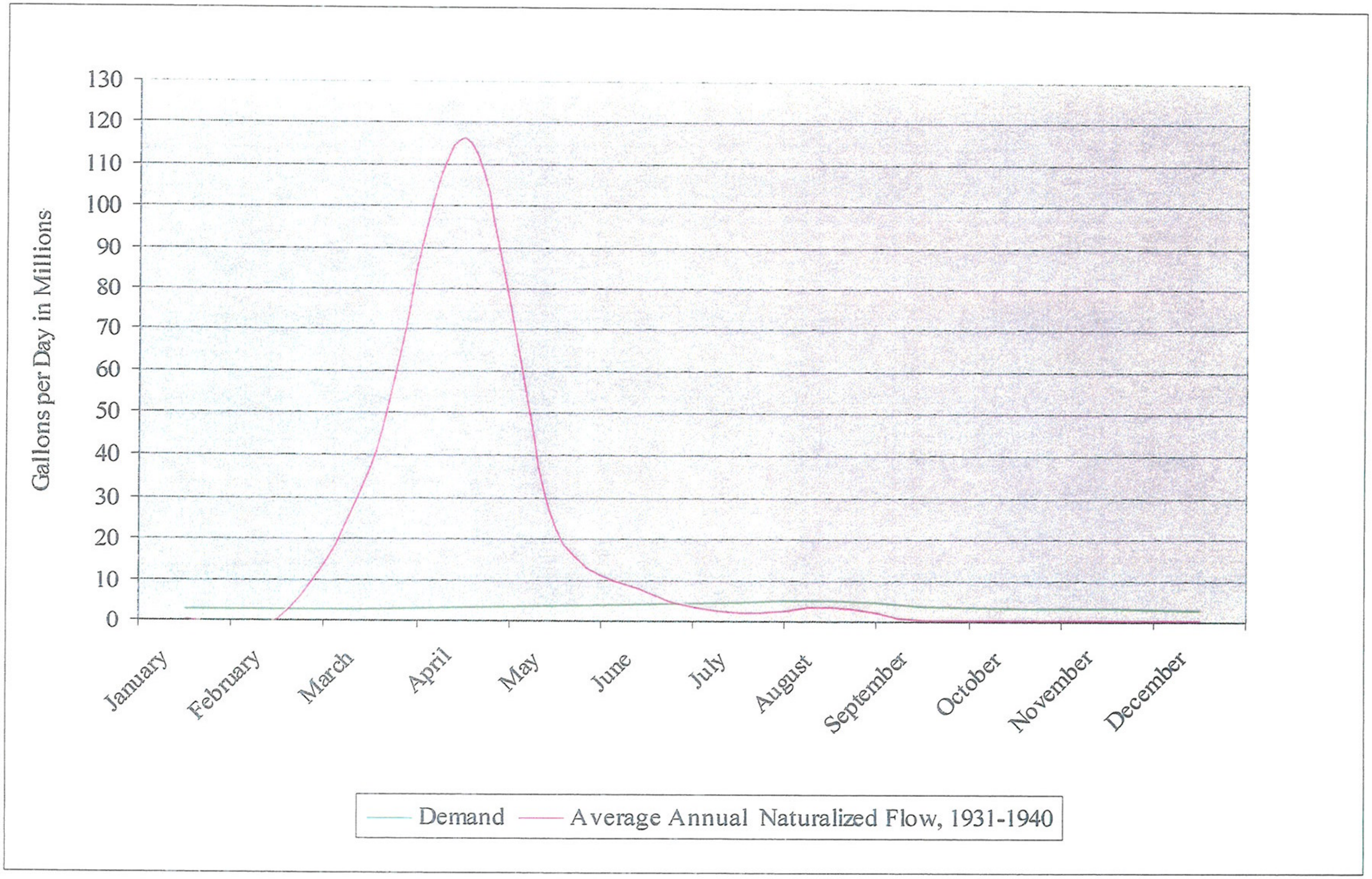
	2050 Average Demand and Available Sheyenne River Flows	**Figure 4**



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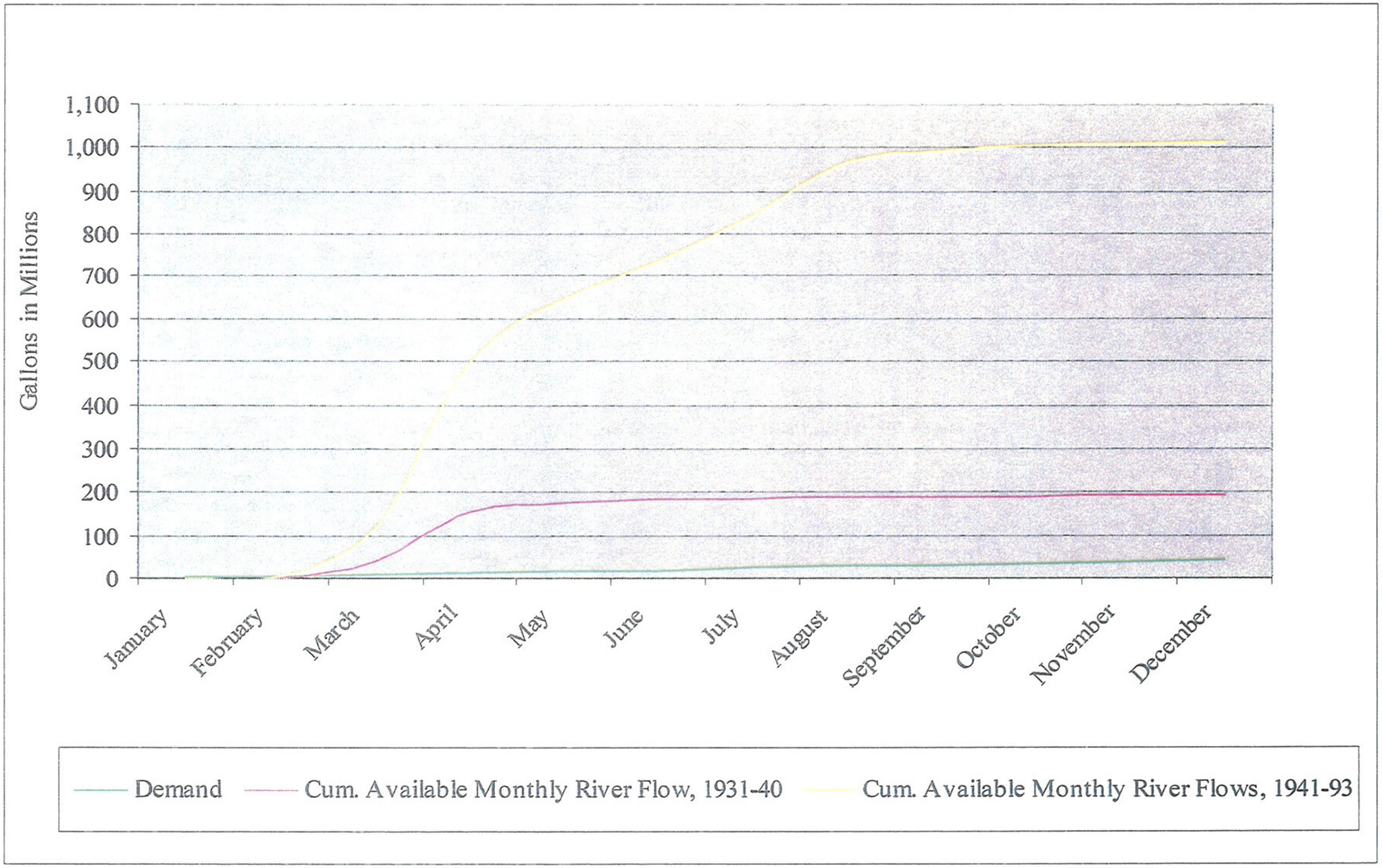
West Fargo: Potable Water Source Assessment	Dec 06
2050 Average Demand and Average Available Drought Sheyenne River Flows	Figure 5



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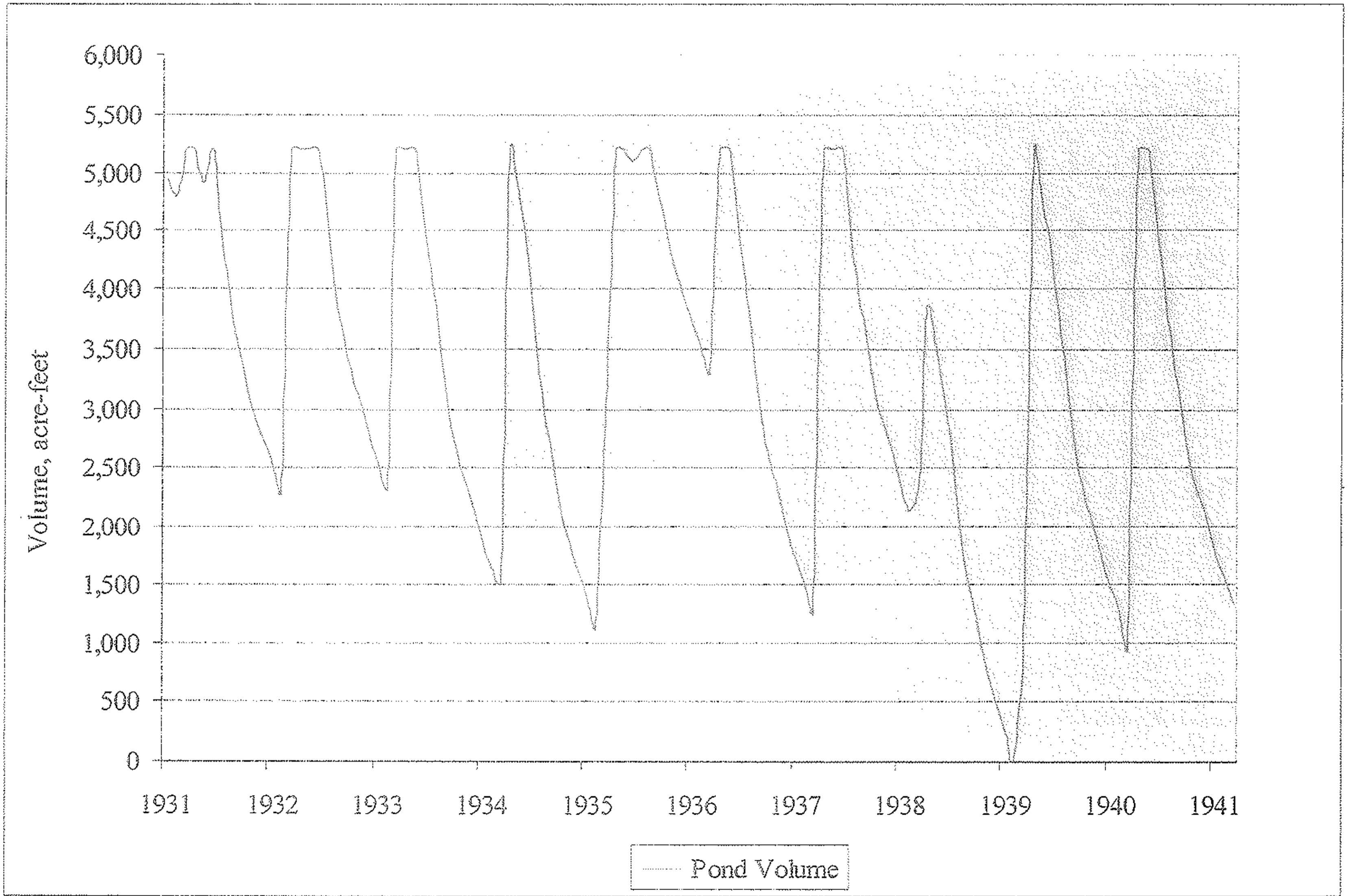
	2050 Cumulative Average Demand and Average Available Sheyenne River Naturalized Flows	Figure 6



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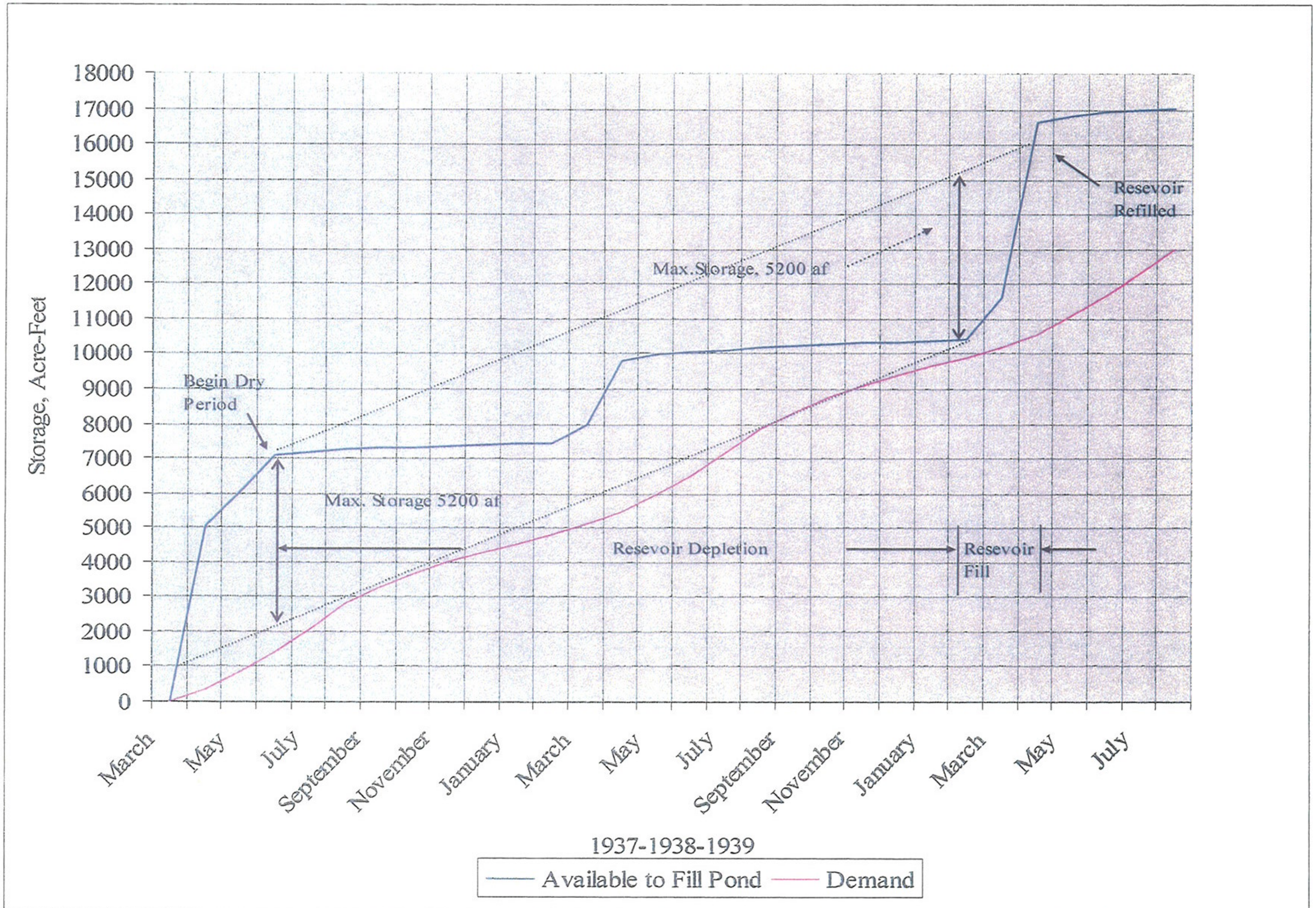
West Fargo: Potable Water Source Assessment

Storage Pond Fill and Draw

Dec 06

Figure 7



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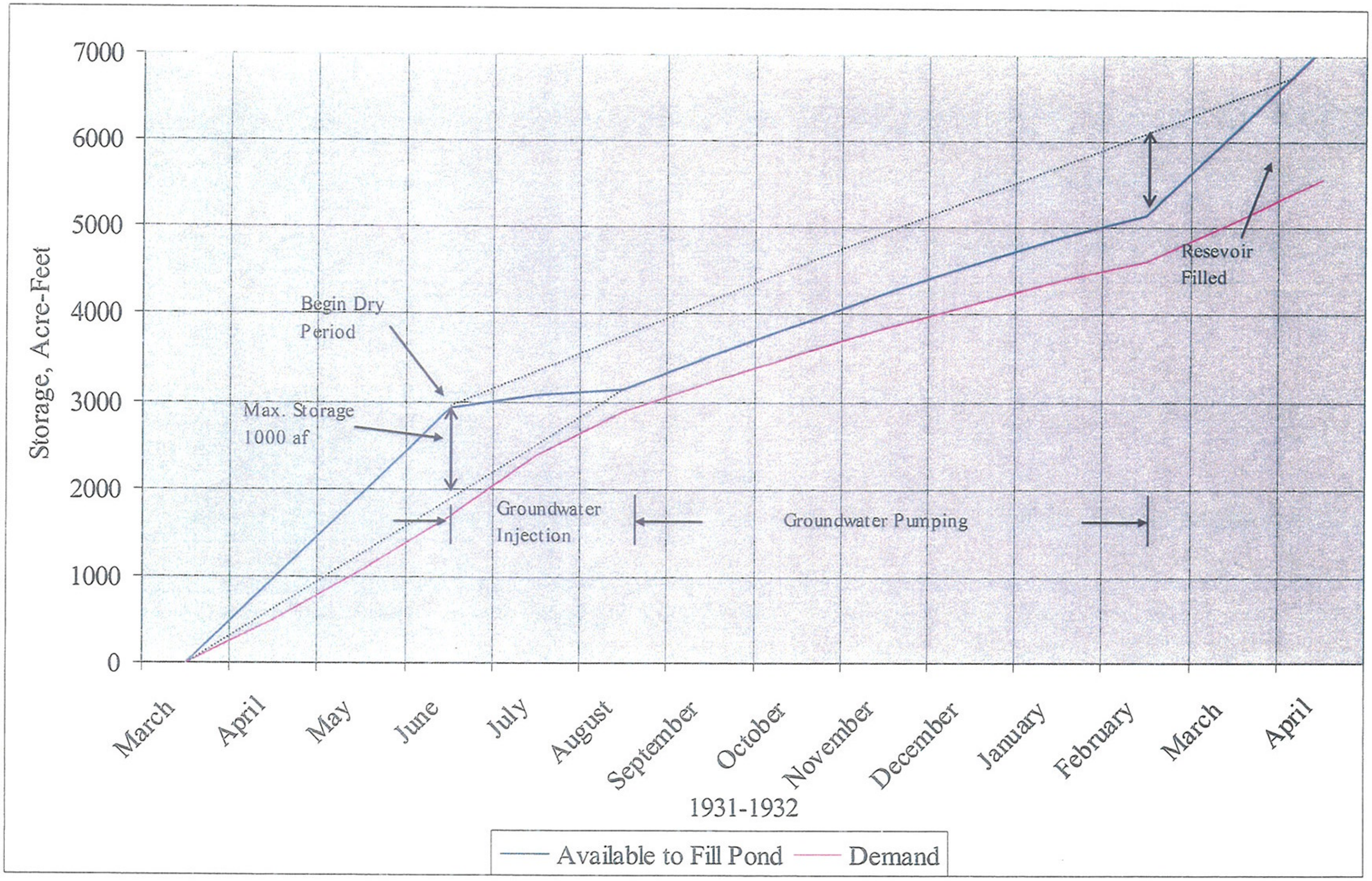
West Fargo: Potable Water Source Assessment

Dec 06

Required Storage with no Groundwater Pumping and Injection

Figure 8



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West Fargo: Potable Water Source Assessment	Dec 06
Required Pond Storage with Groundwater Pumping and Injection	Figure 9

Appendix A

System Capacity Analysis for the Red River Valley Water Supply Project, January 30, 2006

West Fargo: Potable Water Source Assessment

Assumption(s):
Year 2050 Population = 34,705

Average Year Demands w/out Conservation (1988-2001)

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	81.0	80.0	81.0	86.0	105.0	117.0	131.0	136.0	100.0	93.0	87.0	82.0	98.3	3.4	3,819.7	5.3

Average Year Demands w/ Conservation (1988-2001)

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	75.0	74.0	75.0	80.0	98.0	110.0	124.0	129.0	92.0	86.0	81.0	76.0	91.7	3.2	3,563.7	4.9

Worst Historical Year (1988)

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	77.0	78.0	79.0	83.0	114.0	129.0	215.0	150.0	95.0	101.0	91.0	86.0	108.2	3.8	4,205.2	5.8

Worst Historical Year w/ Conservation

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	71.1	72.1	73.1	75.8	106.8	121.8	207.8	142.8	87.8	93.8	85.1	80.1	101.5	3.5	3,946.8	5.5

Reclamation Maximum Month Method w/ Conservation

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	80	82	82	88	107	143	208	157	109	98	109	81	112.0	3.9	4,354.3	6.0

Synthetic Year w/out Conservation

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	85.2	85.2	85.2	95	114	150	215	164	116	105	85.2	85.2	115.5	4.0	4,491.4	6.2

Synthetic Year w/ Conservation

Monthly Demand (gpcd)	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
	79.3	79.3	79.3	88.0	107.0	143.0	208.0	157.0	109.0	98.0	79.3	79.3	108.9	3.8	4,232.9	5.8

Projected Annual Water Supply Shortage (Year 2050)	acre-feet	MGD	cfs
	3,797	3.4	5.2

Revised Planning Demand (Drought Contingency #1)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	79.3	79.3	79.3	88.0	96.3	114.4	145.6	125.6	98.1	88.2	79.3	79.3	96.1	3.3	3,734.6	5.2
Drought Contingency Factor Applied (%)	0	0	0	0	10	20	30	20	10	10	0	0	12%			

Projected Annual Water Supply Shortage DC #1 (Year 2050)	acre-feet	MGD	cfs
	3,170	2.8	4.4

Revised Planning Demand (Drought Contingency #2)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	79.3	79.3	79.3	88.0	91.0	107.3	135.2	109.9	98.1	88.2	79.3	79.3	92.8	3.2	3,609.6	5.0
Drought Contingency Factor Applied (%)	0	0	0	0	15	25	35	30	10	10	0	0	15%			

Projected Annual Water Supply Shortage DC #2 (Year 2050)	acre-feet	MGD	cfs
	3,045	2.7	4.2

Appendix A
System Capacity Analysis for the Red River Valley Water Supply Project, January 30, 2006
West Fargo: Potable Water Source Assessment

Assumption(s):
Year 2050 Population = 34,705

Average Year Demands w/out Conservation (1988-2001)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	81.0	80.0	81.0	86.0	105.0	117.0	131.0	136.0	100.0	93.0	87.0	82.0	98.3	3.4	3,819.7	5.3

Average Year Demands w/ Conservation (1988-2001)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	75.0	74.0	75.0	80.0	98.0	110.0	124.0	129.0	92.0	86.0	81.0	76.0	91.7	3.2	3,563.7	4.9

Worst Historical Year (1988)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	77.0	78.0	79.0	83.0	114.0	129.0	215.0	150.0	95.0	101.0	91.0	86.0	108.2	3.8	4,205.2	5.8

Worst Historical Year w/ Conservation

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	71.1	72.1	73.1	75.8	106.8	121.8	207.8	142.8	87.8	93.8	85.1	80.1	101.5	3.5	3,946.8	5.5

Reclamation Maximum Month Method w/ Conservation

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	80	82	82	88	107	143	208	157	109	98	109	81	112.0	3.9	4,354.3	6.0

Synthetic Year w/out Conservation

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	85.2	85.2	85.2	95	114	150	215	164	116	105	85.2	85.2	115.5	4.0	4,491.4	6.2

Synthetic Year w/ Conservation

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	79.3	79.3	79.3	88.0	107.0	143.0	208.0	157.0	109.0	98.0	79.3	79.3	108.9	3.8	4,232.9	5.8

	acre-feet	MGD	cfs
Projected Annual Water Supply Shortage (Year 2050)	3,797	3.4	5.2

Revised Planning Demand (Drought Contingency #1)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	79.3	79.3	79.3	88.0	96.3	114.4	145.6	125.6	98.1	88.2	79.3	79.3	96.1	3.3	3,734.6	5.2
Drought Contingency Factor Applied (%)	0	0	0	0	10	20	30	20	10	10	0	0	12%			

	acre-feet	MGD	cfs
Projected Annual Water Supply Shortage DC #1 (Year 2050)	3,170	2.8	4.4

Revised Planning Demand (Drought Contingency #2)

	January	February	March	April	May	June	July	August	September	October	November	December	Average	MGD	Acre-Feet per Year	cfs
Monthly Demand (gpcd)	79.3	79.3	79.3	88.0	91.0	107.3	135.2	109.9	98.1	88.2	79.3	79.3	92.8	3.2	3,609.6	5.0
Drought Contingency Factor Applied (%)	0	0	0	0	15	25	35	30	10	10	0	0	15%			

	acre-feet	MGD	cfs
Projected Annual Water Supply Shortage DC #2 (Year 2050)	3,045	2.7	4.2

Appendix B
Estimated Projected Life of Existing Wells after 1999
West Fargo: Potable Water Source Assessment

Well ID	Well Number	Date Drilled	Well Location	Static 1998	Specific Capacity (gpm) 1998	Available Drawdown in 1998	Years Left at 500 gpm	Years Left at 250 gpm
ABM	7	1983	16bdc	112	6.3	99	20	60
Interstate	9	1992	16ccd2	109	8.2	113	52	82
12th Avenue	6	1976	8dcd	136	15.6	47	15	31
Sherman	5	1972	9bba	132	8.5	41	-18	11
Riverside	8	1964	6dcd	134	9.5	53	0	26

Source: Technical Memorandum: Evaluation of the West Fargo Aquifer System, Liesch Associates, Inc., August 13, 1999.

Appendix C
2006 Sheyenne River and West Fargo Stormwater Water Quality Data
West Fargo: Potable Water Source Assessment

Parameter units	MDL	MCL		Sheyenne River April 25, 2006	Sheyenne River August 7, 2006		Stormwater Sample May 4, 2006	Stormwater Sample August 18, 2006
Volatile Organics (method 8260B)	1 - 50 ug/L **	MCL 1		BDL	BDL		BDL	BDL
Pesticides (method 8081A)	0.5 ug/L **	MCL 1		BDL	BDL		NT	NT
Herbicides (method 8151)	2 - 50 ug/L**	MCL 1		BDL	BDL		NT	NT
Base/Neutral Extractables (method 8270C)	10 ug/L **	MCL 1		BDL	BDL		BDL	BDL
Metals								
Arsenic (total) mg/L	0.02 mg/L	0.05		BDL	BDL		BDL	BDL
Antimony (total) mg/L	0.01 mg/L	0.006		BDL	BDL		0.013	BDL
Beryllium (total) mg/L	0.002 mg/L	0.004		BDL	BDL		BDL	BDL
Cadmium (total) mg/L	0.005 mg/L	0.005		BDL	BDL		BDL	BDL
Chromium (total) mg/L	0.01 mg/L	0.1		0.014	BDL		BDL	BDL
Copper (total) mg/L	0.02 mg/L	1.3**		BDL	BDL		BDL	BDL
Lead (total) mg/L	0.005 mg/L	0.015**		BDL	BDL		BDL	BDL
Mercury (total) mg/L	0.0002 mg/L	0.002		BDL	BDL		BDL	BDL
Nickel (total) mg/L	0.02 mg/L	NA		0.022	BDL		BDL	BDL
Selenium (total) mg/L	0.02 mg/L	0.05		BDL	BDL		BDL	0.035
Silver (total) mg/L	0.01 mg/L	NA		BDL	BDL		BDL	BDL
Thallium (total) mg/L	0.001 mg/L	0.002		BDL	BDL		BDL	BDL
Zinc (total) mg/L	0.03 mg/L	NA		0.07	BDL		BDL	0.095
General Inorganics								
Ammonia (as N) mg/L	0.10 mg/L	NA		BDL	0.22		0.78	0.62
Chloride mg/L	1.0 mg/L	NA		NT	NT		86	83
Sulfate mg/L	100 mg/L	NA		NT	NT		3300	5200
Phosphorus, total mg/L	0.1 mg/L	NA		NT	NT		0.22	1.2
Nitrate-Nitrite (as N)	0.1 mg/L	NA		1	BDL		NT	0.19
Nitrate (as N) mg/L	0.1 mg/L	10		NT	NT		1.5	NT
Nitrite (as N) mg/L	0.1 mg/L	1		NT	NT		BDL	NT
pH	S.U.	NA		NT	NT		7.9	7.5
TSS mg/L	1 mg/L	NA		330.0	93.0		9.0	12.0
TDS mg/L	1 mg/L	NA		650	770		5200	7100
Total Solids mg/L	1 mg/L	NA		1060	774		5380	7350

MCL - Maximum Contaminant Level as established by the EPA for public water supplies
MCL[1] = MCLs have been established for only some individual parameters in this group
* = Treatment Technology action level
** = method detection limit will vary for individual parameters quantified by this analytical method
NA - not applicable, not established
MDL - detection limit; detections limits may vary due to interference, sample matrix or lab procedures
BDL - not detected, below laboratory detection limit
NT - not tested, well not in place or parameter not required